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BSI Standards Publication

Electric vehicle battery swap system

Part 1: General and guidance

National foreword

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Electric vehicle battery swap system – Part 1: General and guidance

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRIC VEHICLE BATTERY SWAP SYSTEM –

Part 1: General and guidance

FOREWORD

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- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical Specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62840-1, which is a Technical Specification, has been prepared by IEC technical committee 69: Electric road vehicles and electric industrial trucks.

The text of this Technical Specification is based on the following documents:

Enquiry draft	Report on voting
69/368/DTS	69/399/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62840 series, published under the general title *Electric vehicle battery swap system*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The purpose of the battery swap system is to provide energy partly or in total to electric road vehicles (EVs) through fast replacement of their swappable battery system (SBS). While charging, the EV typically takes a relatively long time, the battery swap process takes only a few minutes to complete. Thus it will reduce range anxiety and will facilitate travel for longer distances.

As there is a possibility to charge the batteries after their removal from the vehicle in various ways, the impact of this process on the critical infrastructure of the electrical grid is minimized.

Battery swap stations mainly include one or more of the following functions:

- swap of EV swappable battery system (SBS);
- storage of EV SBS;
- charging and cooling of EV SBS;
- testing, maintenance and safety management of EV SBS.

This document serves as generic requirements for battery swap systems for EVs.

The IEC 62840 series includes two parts:

- IEC 62840-1: General and guidance;
- IEC 62840-2: Safety requirements.

ELECTRIC VEHICLE BATTERY SWAP SYSTEM –

Part 1: General and guidance

1 Scope

This part of IEC 62840, which is a Technical Specification, gives the general overview for battery swap systems, for the purposes of swapping batteries of electric road vehicles (EVs) when the vehicle powertrain is turned off and when the battery swap system is connected to the supply network at standard supply voltages according to IEC 60038 with a rated voltage up to 1 000 V AC and up to 1 500 V DC.

This document is applicable for battery swap systems for EV equipped with one or more swappable battery system (SBS).

NOTE Battery swap systems for light electric vehicles (LEVs) according to the IEC 61851-3¹ series are under consideration.

This document is not applicable to:

- aspects related to maintenance and service of the battery swap station (BSS);
- trolley buses, rail vehicles and vehicles designed primarily for use off-road;
- maintenance and service of EVs.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60038, *IEC standard voltages*

3 Terms and definitions

3.1

electric vehicle

EV

electric road vehicle

vehicle propelled by an electric motor drawing current from a rechargeable storage battery or from other portable energy storage devices (rechargeable, using energy from a source off the vehicle, such as residential or public electric service), which is manufactured primarily for use on public streets, roads or highways

[SOURCE: ISO 17409:2015, 3.19, modified — Some precisions have been added.]

3.2

battery swap system

battery swap station and supporting systems

¹ Under consideration.

3.3 supporting system

system which serve the battery swap station

3.4 battery swap station

BSS

facility that provides EVs with a swappable battery system (SBS)

3.5 battery pack

energy storage device that includes cells or cell assemblies normally connected with cell electronics, voltage class B circuit and overcurrent shut-off device, including electrical interconnections, and interfaces for external systems

Note 1 to entry: For further explanation, see ISO 12405-1:2011, 5.4 and Clause A.2.

Note 2 to entry: Examples of external systems are cooling, voltage class B, auxiliary voltage class A and communication.

[SOURCE: ISO 12405-1:2011, 3.2]

3.6 swappable battery system

SBS

battery pack with a coupler for connecting charger/electric vehicle (EV), lock/unlock devices, battery control unit (BCU), thermal management unit, electrical protection circuit, enclosure and supporting devices

3.7 battery system

energy storage device that includes cells or cell assemblies or battery pack(s) as well as electrical circuits and electronics

Note 1 to entry: For further explanation, see ISO 12405-1:2011, 5.5.2, 5.5.3, A.3.1 and A.3.2. Battery system components can also be distributed in different devices within the vehicle.

Note 2 to entry: Examples of electronics are the BCU and contactors.

[SOURCE: ISO 12405-1:2011, 3.3]

3.8 swappable battery system coupler

SBS coupler

dedicated coupler for connecting a swappable battery system to an electric vehicle (EV) or to a charging rack

3.9 SBS charger swappable battery system charger

device installed outside the EV to supply DC power to a swappable battery system (SBS) or a series of SBS

3.10 charging rack

equipment used for carrying a swappable battery system (SBS) and connecting a SBS to a charger to accomplish the charge process

3.11**storage rack**

equipment used to store a swappable battery system (SBS)

3.12**transferring equipment**

equipment used for transferring a swappable battery system (SBS) inside a battery swap station (BSS)

3.13**battery swap equipment
swap equipment**

equipment used for mounting/unmounting a swappable battery system (SBS) to/ from electric vehicles (EVs)

Note 1 to entry: The battery transferring function may be integrated in the battery swap equipment.

3.14**battery control unit****BCU**

electronic device that controls, manages, detects or calculates electric and thermal functions of the battery system and that provides communication between the battery system and the battery swap system

[SOURCE: ISO 12405-1:2011, 3.1, modified — The words "other vehicle controllers" have been replaced by "the battery swap system".]

3.15**human machine interface****HMI**

interface between operating staff and the instrumentation and computer systems connected to the plant

Note 1 to entry: In this case, the plant refers to BSS.

[SOURCE: IEC 60050-395:2014, 395-07-48, modified — The note to entry has been replaced by a new note.]

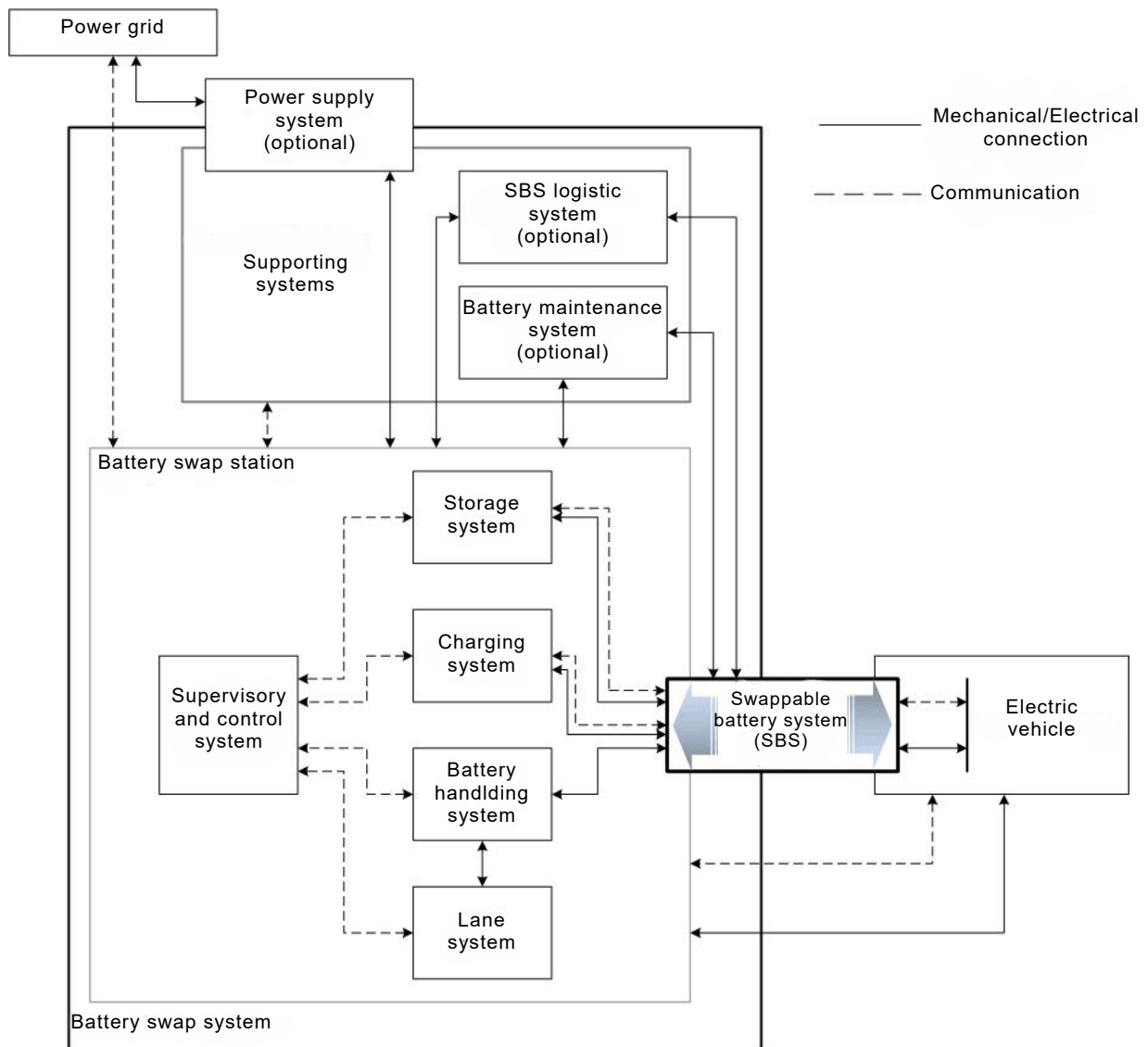
4 System overview**4.1 Battery swap system**

Battery swap systems provide quick, safe and reliable swapping of the swappable battery system (SBS) of electric vehicles (EVs). The batteries will be loaded in a battery swap station (BSS). The SBS are stored in a battery rack in the BSS. The battery swapping is carried out by means of appropriate manipulators.

EV battery swap system consists of:

- BSS,
- supporting systems,
- SBS, and
- power supply system.

Figure 1 shows the composition of the EV battery swap system and the relationships between the various systems.



IEC

Figure 1 – EV battery swap system

4.2 Battery swap station

4.2.1 General description

BSS consists of systems, which provide battery mounting/unmounting, battery transfer, battery storage, battery charging and other functions. BSS may include:

- a lane system,
- a battery handling system,
- a storage system,
- a charging system, and
- a supervisory and control system.

4.2.2 Lane system

The lane system is used to transfer and/or position the EV to the designated location to get ready for battery handling. EVs leave safely through the lane system after SBS are exchanged. The lane system may provide functions such as:

- EV verification,
- EV validation,
- EV cleaning,
- EV positioning, and
- EV locking and unlocking.

The lane may include a cleaning station for the purposes of cleaning EV/battery parts before the swap process starts.

4.2.3 Battery handling system

The battery handling system consists of swap equipment and transferring equipment.

The system may provide functions such as:

- locking/unlocking,
- mounting/un-mounting, and
- transferring.

4.2.4 Storage system

The storage system is used to store the SBS safely. It shall monitor the status of the SBS and the ambient circumstances during storage.

This system consists of:

- a storage rack, and
- an equipment to communicate with supervisory and control system.

4.2.5 Charging system

The charging system is used to charge the SBS safely. It shall carry the SBS in the charging rack, communicate with the battery control unit (BCU) during the charging procedure, and control the charging procedure and its safe operation.

This system consists of:

- SBS charger(s),
- charging racks, and
- equipment to communicate with supervisory and control system.

4.2.6 Supervisory and control system

The supervisory and control system contains

- communication units,
- a data process module,
- data acquisition units,
- a data storage module,
- a remote control module, and
- a human machine interface (HMI).

The supervisory and control system monitors and controls all battery swap system processes.

This system may have communication with the power grid as well.

4.3 Supporting systems (optional)

4.3.1 General supporting systems

Supporting systems consist of equipment which assists in completing the battery swap process.

Supporting systems may include:

- a SBS logistic system, and
- a battery maintenance system.

4.3.2 SBS logistic system

SBS logistic system shall exchange and transport SBS between BSS and external facilities or EVs. Also, SBS logistic system can be used to charge an EV in emergency cases. It provides service and communication between BSS and external facilities or EVs in order to support the transportation of SBS.

4.3.3 Battery maintenance system

Battery maintenance system provides online or offline inspection and maintenance on SBS in order to ensure safety, reliability and to extend the lifetime of SBS.

4.4 Swappable battery system

Swappable battery system is the object of a battery swap system. A battery swappable vehicle has one or more swappable battery systems, which can be mounted or unmounted separately by the battery handling system.

4.5 Power supply system

Power supply system supplies electric power to the BSS and the supporting systems. Reverse power flow implementation is under consideration.

4.6 Interfaces

Interfaces in an EV battery swap system can be divided into internal interfaces and external interfaces according to the different functions of the systems. The external interfaces refer to physical (electrical connection, mechanical lock, steering etc.) and logical (communication protocols) interfaces between the battery swap system and other systems. The internal interfaces refer to physical and logical interfaces between systems within the battery swap system, including interfaces between the BSS and the supporting systems.

NOTE Interfaces are specified in the relevant part of the IEC 62840 series, which is under consideration.

External interfaces include:

- the interface between the SBS and the EV,
- the interface between the BSS and the EV,
- the interface between the power supply system and the power grid, and
- the interface between the battery swap station and the power grid;

Internal interfaces include:

- the interface between the BSS and the supporting systems,
- the interface between the supervisory and control system and the storage system,
- the interface between the supervisory and control system and the charging system,

- the interface between the supervisory and control system and the battery handling system,
- the interface between the supervisory and control system and the lane system,
- the interface between the battery handling system and the lane system,
- the interface between the storage system and the SBS,
- the interface between the charging system and the SBS,
- the interface between the battery handling system and the SBS,
- the interface between the SBS logistic system and the battery swap station,
- the interface between the SBS logistic system and the SBS,
- the interface between the battery maintenance system and the BSS,
- the interface between the battery maintenance system and the SBS, and
- the interface between the battery swap station and the power supply system.

4.7 Zones

4.7.1 General

The battery swap system is divided into 4 separate zones with different accessibility patterns:

- vehicle lane zone,
- battery swap zone,
- battery storage zone, and
- battery charging zone.

4.7.2 Vehicle lane zone

The vehicle lane zone provides access for the EV to the BSS and the battery swap zone. Table 1 shows accessibility of vehicle lane zone, which can be different according to local regulations or system requirements.

Table 1 – Accessibility of vehicle lane zone

Role	Action	Vehicle lane zone
		Accessibility
EV driver	Access	Fully authorized
	Operate	Conditional
	Maintenance	Forbidden
Station operating personnel	Access	Fully authorized
	Operate	Fully authorized
	Maintenance	Forbidden
Station maintenance personnel	Access	Fully authorized
	Operate	Forbidden
	Maintenance	Fully authorized

4.7.3 Battery swap zone

The battery swap zone defines where automatic/semi-automatic devices are mounting/unmounting SBS to and from the electric vehicles. Table 2 shows accessibility of battery swap zone, which can be different according to local regulations or system requirements.

Table 2 – Accessibility of battery swap zone

Role	Action	Battery swap zone
		Accessibility
EV driver	Access	Conditional
	Operate	Conditional
	Maintenance	Forbidden
Station operating personnel	Access	Fully authorized
	Operate	Fully authorized
	Maintenance	Forbidden
Station maintenance personnel	Access	Fully authorized
	Operate	Forbidden
	Maintenance	Fully authorized

4.7.4 Battery storage zone

The battery storage zone defines where SBS are stored, and manipulated by automatic/semi-automatic devices. Table 3 shows accessibility of battery storage zone, which can be different according to local regulations or system requirements.

Table 3 – Accessibility of battery storage zone

Role	Action	Battery storage zone
		Accessibility
EV driver	Access	Forbidden
	Operate	Forbidden
	Maintenance	Forbidden
Station operating personnel	Access	Fully authorized
	Operate	Fully authorized
	Maintenance	Forbidden
Station maintenance personnel	Access	Fully authorized
	Operate	Forbidden
	Maintenance	Fully authorized

4.7.5 Battery charging zone

The battery charging zone defines where SBS are charged. Battery storage zone and battery charging zone can be the same physical location. This means the battery can be charged while it is stored. Table 4 shows accessibility of battery charging zone, which can be different according to local regulations or system requirements.

Table 4 – Accessibility of battery charging zone

Role	Action	Battery charging zone
		Accessibility
EV driver	Access	Forbidden
	Operate	Forbidden
	Maintenance	Forbidden
Station operating personnel	Access	Fully authorized
	Operate	Fully authorized
	Maintenance	Forbidden
Station maintenance personnel	Access	Fully authorized
	Operate	Forbidden
	Maintenance	Fully authorized

5 Classification

5.1 General

The BSS is classified as follows:

- according to automation level;
- according to SBS mounting direction;
- according to the swappable EV category.

5.2 Automation level

5.2.1 General

Automation levels are classified as follows:

- full automatic;
- semi-automatic;
- manual.

5.2.2 Full automatic

The full automatic battery swap processes includes:

- positioning the vehicle,
- swapping the SBS from/to the vehicle,
- transferring the SBS from/to the storage system,
- storing the SBS, and
- charging the SBS.

The full automatic battery swap process is operated by the automatic electrical/mechanical systems, without any human labour.

5.2.3 Semi-automatic

The semi-automatic battery swap process includes:

- positioning the vehicle,

- swapping the SBS from/to the EV,
- transferring the SBS from/to the storage system,
- storing the SBS, and
- charging the SBS.

The semi-automatic battery swap process is initiated and controlled by human operator while assisted by the electrical/mechanical systems equipped with sensors or other automatic devices.

5.2.4 Manual mode

The manual battery swap process is initiated, operated and controlled by human operators. In some cases, the operators may use electromechanical devices to assist.

5.3 SBS swapping direction

The physical direction of SBS swapping is classified as follows:

- side-swapping;
- bottom-swapping;
- top-swapping;
- front-swapping;
- rear-swapping;
- multiple direction.

Annex B contain examples for specific designs and technologies which are used in the different types of battery swap patterns.

5.4 EV categories

EV categories according to ISO 3833 or UNECE R100 are classified as follows:

- M1, swapping for passenger car;
- M2, M3, N1, N2, N3, swapping for commercial vehicle.

5.5 Environmental conditions

The battery swap system can be classified according to its suitability for use in severe environmental conditions other than those specified in this specification, if declared so by the manufacturer.

Where any special service conditions specified by the client exist, a special agreement regarding testing shall be made between the battery swap system manufacturer and the client.

Annex A (informative)

Use case

A.1 Use case for positioning vehicle

Table A.1 shows the use case for positioning of the vehicle.

Table A.1 – Use case for positioning vehicle

Use case name	Positioning vehicle
Scope	To guide and/or position EV in battery swap workspace via lane system
Description	<ol style="list-style-type: none"> 1) EV verification and validation 2) EV enters into the battery swap station 3) Cleaning the EV if necessary 4) Leading the vehicle into the battery swap workspace in right position (if needed) and locked (if needed) 5) Unlocked (if needed) and EV drives out
Users/actors	EV, Supervisory and control system, Lane system
Special requirements	<ol style="list-style-type: none"> 1) EV verification and validation shall be accomplished via wireless devices such as radio frequency identification (RFID), reporting to the supervisory and control system. 2) It is recommended that the EV is cleaned before the battery is swapped if the SBS is mounted in the chassis of the vehicle body.

A.2 Use case for swapping battery pack

Table A.2 shows the use case for swapping battery pack.

Table A.2 – Use case for swapping battery pack

Use case name	Swapping battery pack
Scope	To transfer and mount/unmount SBS in the vehicle via handling devices
Description	<ol style="list-style-type: none"> 1) Start process, unlock the SBS. 2) The handling devices transfer the charged SBS from the battery storage system. 3) The handling devices unmount the depleted SBS out from the vehicle body according to the supervisory and control system or according to the operator. 4) The handling devices mount the charged SBS into the vehicle body according to the command from supervisory and control system or from the operator. 5) The handling devices transfer the depleted SBS back to the battery storage system. 6) Lock the SBS and terminate the process.
Users/actors	EV, SBS, battery handling system, battery storage system, supervisory and control system, operator
Special requirements	<p>When handling devices malfunction in the process of a battery swap, the handling devices should stop and send an abnormal signal to supervisory and control system.</p> <p>This process should be done while the passengers are getting on and off.</p>

A.3 Use case for charging SBS

Table A.3 shows the use case for charging SBS.

Table A.3 – Use case for charging SBS

Use case name	Charging SBS
Scope	Charge SBS via charger
Description	After the SBS has been transferred into the charging rack (charging system), the charging system begins the charge process. The charger adjusts the charging parameters according to the requests from BCU in SBS and then sends the acquired data to the supervisory and control system.
Users/actors	SBS, charging system, supervisory and control system
Special requirements	<ol style="list-style-type: none"> 1) The supervisory and control system sends a command to the SBS charger to suspend charging when it receives the alarm signal from a smoke detector or other detection device. 2) The SBS charger suspends charging and sends the abnormal stop message to the supervisory and control system when it receives the abnormal signal from BCU or from itself.

A.4 Use case for maintaining SBS

Table A.4 shows the use case for maintaining SBS.

Table A.4 – Use case for maintaining SBS

Use case name	Maintaining SBS
Scope	Ensure the safety and life cycle of the SBS by inspecting and maintaining via battery maintenance system
Description	According to a pre-defined maintenance cycle, or if the performance of the SBS is abnormal during charging or storage, the supervisory and control system or the operator orders the transfer of the SBS from the charging/storage system to the maintenance system. The battery maintenance system then inspects and maintains the SBS.
Users/actors	Battery maintenance system, supervisory and control system, SBS, storage system, operator
Special requirements	Maintenance shall be online or off-line.

A.5 Use case for emergency charging vehicle

Table A.5 shows the use case for emergency charging vehicle.

Table A.5 – Use case for emergency charging vehicle

Use case name	Emergency charging vehicle
Scope	To charge EV in emergency case
Description	<ol style="list-style-type: none">1) The SBS logistics system receives an emergency charging request.2) The SBS logistics system moves to the location of EV.3) The power cable is connected between SBS logistics system and the EV.4) The SBS in EV is charged using battery packs in the SBS logistics system.5) The power cable is disconnected.
Users/actors	Battery logistics system, EV
Special requirements	Connecting and disconnecting power cable should be done manually.

Annex B (informative)

Battery swap station solutions

B.1 General

According to the classification of BSS in 5.2 and 5.3, some of the BSS solutions are introduced in Annex B, as shown in Table B.1.

Table B.1 – Key index of the systems in different types of battery swap stations

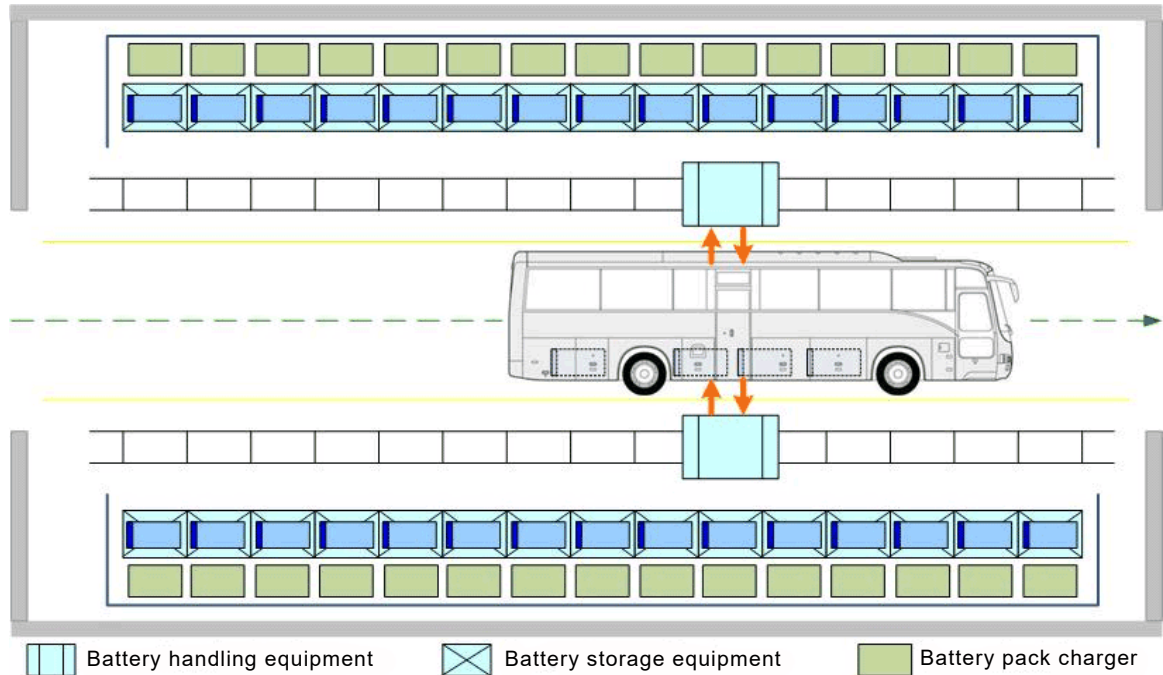
System	Index	B.2.1	B.2.2	B.3.1	B.3.2	B.3.3
		Commercial vehicle	Commercial vehicle	Passenger car	Passenger car	Passenger car
		Automatic	Automatic	Semi-auto	Automatic	Automatic
		Side-swap	Top-swap	Rear-swap	Bottom-swap	Side-swap
Lane system	vehicle entrance (verification and validation)	•	•		•	•
	vehicle cleaning					
	vehicle positioning	•	•	•	•	•
	vehicle locking (if needed)					
	vehicle unlocking (if needed)					
	vehicle drive out	•	•	•	•	•
Handling system	start of process	•	•	•	•	•
	unlocking SBS	•	•	•	•	•
	disconnecting SBS	•	•	•	•	•
	removing depleted SBS vehicle	•	•	•	•	•
	taking away depleted SBS	•	•	•	•	•
	bring charged SBS from storage system	•	•	•	•	•
	moving charged SBS inside vehicle	•	•	•	•	•
	connecting SBS	•	•	•	•	•
	locking SBS	•	•	•	•	•
	termination of process	•	•	•	•	•
Storage system	storage rack	•	•	•	•	•
	locking devices	•	•	•	•	•
	thermal unit	•	•	•	•	•
	connecting devices	•	•		•	•
	monitoring and detection sensor		•			
Charging system	SBS charger	•	•	•	•	•
	charging rack	•	•	•	•	•
	charger controller	•	•	•	•	•
	connecting devices		•			
	communication with BCU	•	•	•	•	•
Supervisory and control system	monitor and control handling system	•	•		•	•
	monitor and control charging system	•	•	•	•	•
	monitor and control storage system	•	•		•	
	monitor and control power supply system	•	•		•	•
	monitor and control lane system	•	•		•	
	communication with the grid	•			•	

B.2 Commercial vehicles battery swap station

B.2.1 Automatic side-swapping station

Application scope: Applicable to commercial EVs, such as buses and sanitation trucks, which have battery packs installed in both sides of the vehicle body.

Composition of the working zone: The layout of the working area with the major equipment is shown as Figure B.1. Usually, this system consists of two sets of battery swap equipment, storage equipment, chargers, and one lane.



IEC

Figure B.1 – Automatic side-swapping station layout

Characteristics of the solution: The whole battery swapping, charging, and other management processes, should be automatically accomplished under the control of a supervisory and control system. This mode is of a high degree of automation, and requires a relatively large construction investment.

B.2.2 Automatic top-swapping station

Application scope: Applicable to commercial electric buses which have battery mounting module with sliding roof door.

Composition of the working zone: The layout of the working area's major equipment is shown in Figure B.2. Quick battery exchanging machine (QCM) with the swap equipment, charging (storage) racks, chargers is embedded on top of the bus stop structure.



Figure B.2 – Automatic top-swapping station layout

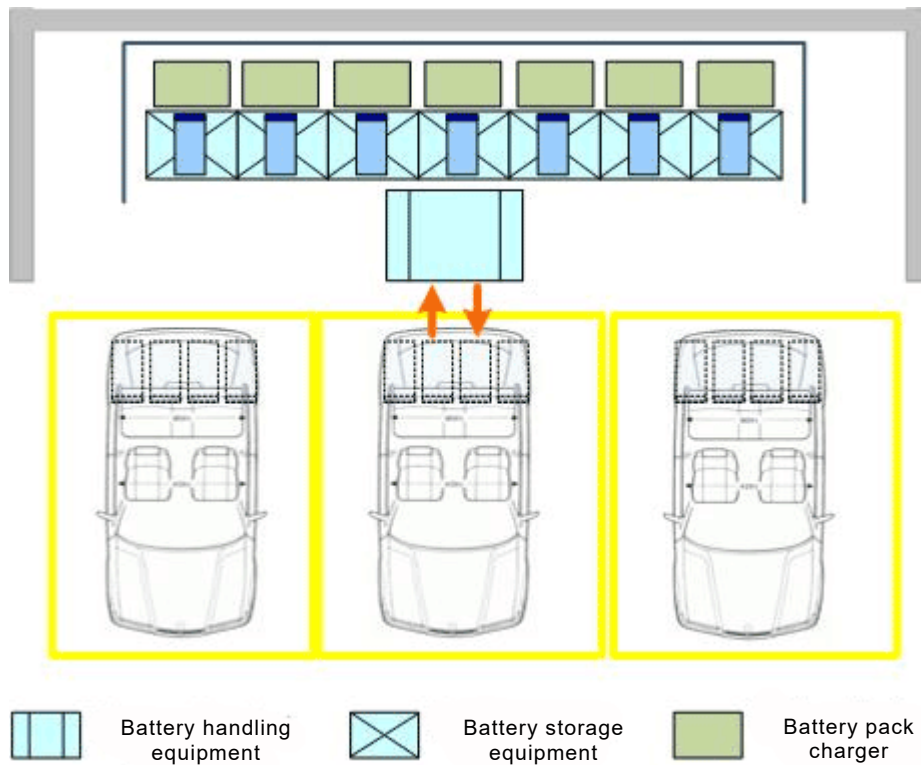
Characteristics of the solution: The whole battery swap, charge, and other management processes are automatically accomplished under the control of a supervisory and control system. This is an automatic battery swapping system and requires relatively small area and construction investment since it should be built at normal bus stops. A discharged battery is quickly replaced with the charged battery while the passengers are getting on and off.

B.3 Passenger cars battery swap station

B.3.1 Semi-automatic rear-swapping station

Application scope: Applicable to electric passenger vehicles, such as private cars and taxis, with battery packs installed in the trunk of the vehicle body.

Composition of the system: The layout of the working area's major equipment is shown in Figure B.3. Usually, this system consists of one or more sets of battery swap equipment, storage equipment, chargers, and lanes.



IEC

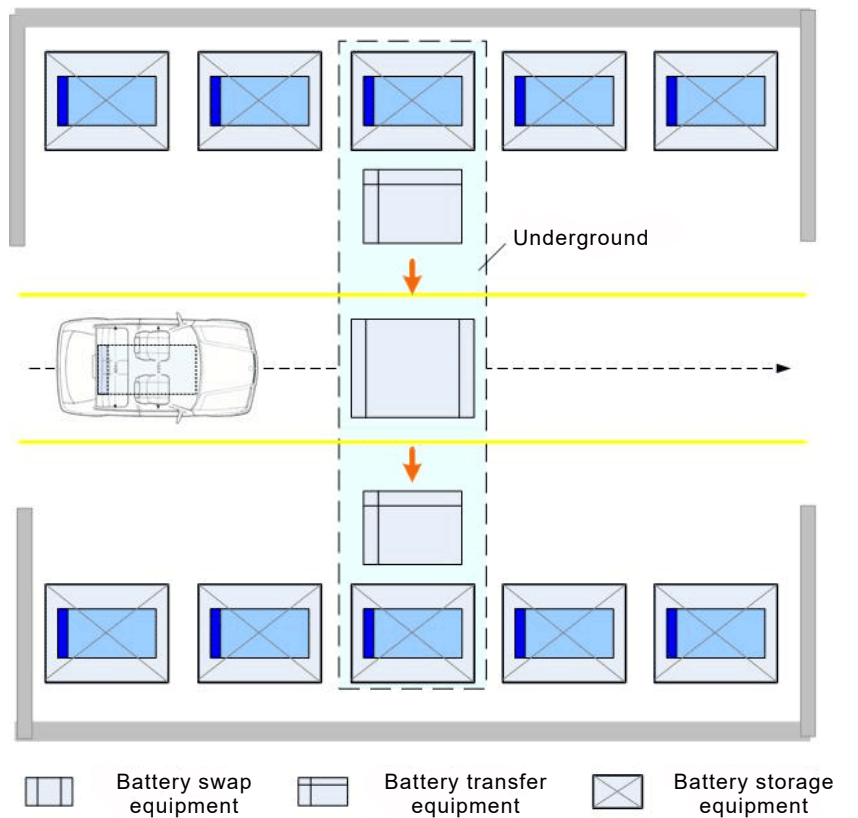
Figure B.3 – Semi-automatic rear-swapping station layout

Characteristics of the solution: Battery packs are conveyed by automatic electromechanical devices, and battery swapping is accomplished manually. The deployment may be flexible and construction investment may be relatively small. However, this requires large labour work, thus is not suitable for regions with a high labour cost.

B.3.2 Automatic bottom-swapping station

Application scope: Applicable to electric passenger vehicles, such as private cars and taxis, with battery packs installed in the chassis of the vehicle body.

Composition of the system: The layout of the working area’s major equipment is shown in Figure B.4. Usually, this system consists of one set of battery swap equipment that is below the bottom of the vehicle, two sets of transferring equipment, storage equipment that is arranged by both sides of the vehicle, and the lane.



IEC

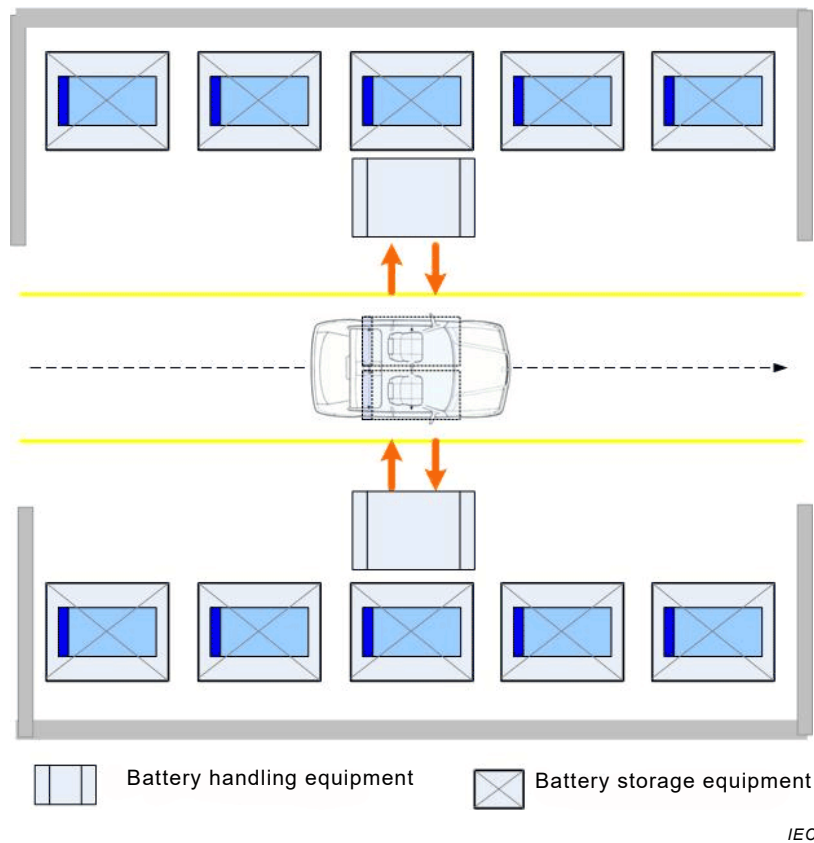
Figure B.4 – Automatic bottom-swapping station layout

Characteristics of the solution: The transferring, swapping, storage and charge process of battery packs should be automatically accomplished under the control of supervisory system. This is of a high degree of automation, and requires a relatively large area and construction investment.

B.3.3 Automatic side-swapping station

Application scope: Applicable to electric passenger vehicles, such as private cars and taxis, with battery packs installed in the chassis of the vehicle body.

Composition of the system: The layout of the working area's major equipment is shown in Figure B.5. Usually, this system consists of two sets of battery swap equipment that are on both sides of the vehicle, storage equipment and the lane.



IEC

Figure B.5 – Automatic side-swapping station layout

Characteristics of the solution: The handling, storage and charge process of battery packs should be automatically accomplished under the control of supervisory system. This is of a high degree of automation, and requires a relatively large area and construction investment.

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² Under consideration.

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